

APRIL 2000 VOL. XXIV NO. 2

# VISIONS



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QUALITATIVE RESEARCH  
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PRODUCT DEVELOPMENT & MANAGEMENT ASSOCIATION  
*Serving people with a professional interest in new products*

## PRODUCT DEVELOPMENT & MANAGEMENT ASSOCIATION

*Serving people with a professional interest in new products*

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### DUE DATE FOR NEXT ISSUE

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# MEASUREMENTS FOR PRODUCT DEVELOPMENT ORGANIZATIONS

## A Perspective from the Theory of Constraints

by Eugene Kania, Lucent Technologies (ekania@lucent.com)

For nearly all product development organizations, speed is everything. Yet, the measurements that are so often available to the managers of such organizations can drive decisions that result in everything but speed.

Dr. E.M. Goldratt's Theory of Constraints (TOC)-based Critical Chain Method enables the development of a comprehensive set of operational and performance measurements for product development organizations that is far more effective than any other measurements in use today. With a TOC-based system of measurements, managers are able to make day-to-day decisions that are consistently in the best interest of their business and directly improve their performance and the bottom line. Furthermore, managers are able to truly align the strategies of the business with the day-to-day behaviors of the people doing the work.

"Tell me how you are going to measure me and I will tell you how I will behave." This short quote from Dr. E.M. Goldratt, pioneer of the Theory of Constraints (TOC), sets the stage for all the discussions ahead. It points out that business measurements can, at the same time, be our best friend and our worst enemy. It points out that effective measures are generally tied to an individual's behavior rather than their output or performance. While this may cause those who manage by objective to cringe, we will see that Goldratt's view is entirely consistent with that of quality guru, Dr. W. Edwards Deming.

### THE MEASUREMENTS TRIANGLE

The measurements triangle is shown in Figure 1. Performance measurements are just that: measures of our performance. For an athlete, it may be goals scored or number of rebounds. For an automobile driver, it may be miles per gallon. For a business manager, it may be on-time delivery percentage or number of customer complaints per month. Performance measurements are generally a "rear view mirror" look as to what happened usually over a long horizon of time like a month, quarter or year. Performance measurements are usually framed as results that allow us to evaluate how we did. From perfor-

mance measurements we can learn lessons from the past.

Operational measurements are measurements that we use to make day-to-day operational decisions. For an athlete, it may be the speed or rotation of the baseball. For an automobile driver, it may be the speedometer reading. For a business manager, it may be an SPC control chart. Operational measurements are generally an "out the windshield" look of what is happening now. As such, they are usually instantaneous or short term (hourly, daily, weekly) measurements. Operational measurements are usually framed as questions and make up the foundation of a feedback loop. That is to say that the operational measurement leads us to make a decision that usually affects the value of that measurement.



Figure 1 The Measurements Triangle

Individual measurements are those measurements in a system of measurements that are focused on individuals in an organization. For a salesman, it may be number of sales calls made. For an engineer, it may be the number of new designs generated. Ostensibly, they are intended to motivate individuals to perform or operate in a way that will contribute to improving the bottom line of the business.

### A SURVEY AND HISTORY OF MEASUREMENTS

(The author would like to acknowledge and thank Tony Rizzo for his significant contributions to this survey and history section of the paper.)

In the beginning, you had revenue, profit

and return on investment (ROI). These are nice, simple, classic business measurements which are useful to a business and which are required for external reporting today to places like the IRS and Wall Street. They measure business performance in that they tell us how we did over the last quarter or year, typically. They are not very useful as operational measurements in that they generally are not useful for day-to-day operational decision making.

The new generation of managers coming out of MBA schools all around the world would call the above old business measurements. They tend to replace these measurements with new business measurements like EVA, CVA and PVA (economic, customer and people value added). This gives way to the enamored concept of the Balanced Scorecard. But, alas, these new measurements, like the old measurements, fall into the same category of performance measurements, which tell us how we did, but offer no guidance for day-to-day operational decision making.

Another way to look at it is to recognize that these old and new business measurements are used to measure the global or system level goals of the organization or business. Historically therefore, the challenge for management has been to take these global goals and translate them down to a set of local goals that apply to functional or project teams and further translate them down to individuals. The common thinking is that people or teams that are achieving their local goals will be contributing positively to the global goals of the business.

When we translate some combination or subset of the old or new business measurements to pieces of the overall organization, we spawn local measurements. For example, if our global goal is a certain level



Eugene Kania

of revenue, we may reason that to reach that revenue level, we need to ship so much product, which means that engineering must generate so many new designs, which means that marketing must conduct so many focus group studies, etc. The number of products shipped by manufacturing, and the number of designs generated by engineering and the number of focus group studies conducted by marketing can all become localized measurements. We can establish local goals for each of these, but how can we guarantee that reaching these local goals will contribute positively to the global goal of the business? For example, in a given month, manufacturing could double its goal of number of products shipped. But, if the products shipped were obsolete inventory that a customer took at a severely discounted price, this could have still resulted in a revenue shortfall for the month.

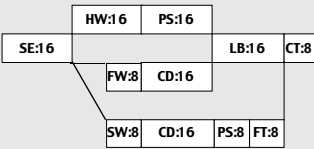
The next step in the evolution of measurements has been to take local measurements and normalize them. Examples of normalized, local measurements are number of drawings per designer, number of lines of code per software engineer, number of sales calls per salesman. By their nature, normalized, local measurements are often used to measure individual performance. This brings us immediately back to Goldratt's haunting quote: "Tell me how you are going to measure me and I will tell you how I will behave." Let's take the example of number of drawings per designer. Their behavior under such a measurement might be to avoid helping to solve production issues related to earlier designs that they may have generated. Their measurement doesn't reward them for such behavior. They may choose not to participate in new product planning activities. This could spawn new product ideas that may seem feasible to product management, but are flawed from a design point of view. This typically leads to a lot of "churn" in the product development organization. Again, their measurement doesn't reward them for such behavior.

Where things really take a turn for the worse is when middle or front line managers are tempted to take these performance measurements and try to use them as operational measurements. Managers may be tempted to schedule overtime (an operational decision) so the engineers have more time to generate more code. Or, they may be pressured to reduce headcount (an operational decision) so that the normalized measurement makes a quick improve-

# Goldratt's Critical Chain Method

First introduced in 1997 by Dr. Eliyahu M. Goldratt in his book *Critical Chain*, the Critical Chain Method essentially seeks to squeeze contingency or safety out of individual tasks in a project plan and aggregate this contingency or safety in strategic locations in the project plan. The contingency is, therefore, owned by the project or system and not by the individual task owners.

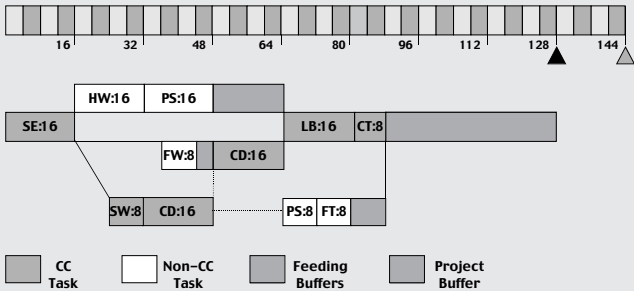
A Critical Chain project plan is built on the foundation of a disciplined project planning process which yields a plan with the following characteristics: a logical network of tasks and task dependencies which delivers an objective, resources assigned to each task, and time duration estimates for each task which do not include individual task contingency or safety. Here is an example of such a plan:



## THE CRITICAL CHAIN METHOD OPERATES ON THIS PLAN IN A 4-STEP PROCESS:

1. Level the resource load in the project to eliminate resource contention.
2. Identify the Critical Chain which is the longest path through the network considering both task and resource dependencies.
3. Protect the project due date by aggregating contingency time in the form of a Project Buffer at the end of the Critical Chain. The Project Buffer is used to absorb uncertainty or disruptions that may occur on the Critical Chain of the project.
4. Protect the Critical Chain itself by aggregating contingency time at all points where non-Critical Chain tasks feed into the Critical Chain. These Feeding Buffers are used to absorb uncertainty or disruptions that may occur in non-Critical Chain tasks.

## THE FOLLOWING IS A CRITICAL CHAIN PROJECT PLAN DERIVED FROM THE EXAMPLE ABOVE USING THIS 4-STEP PROCESS:



A single project has a single Project Buffer and numerous feeding buffers depending on the complexity of the project. In a product development system where multiple projects are occurring simultaneously, the Critical Chain Method yields a matrix or system of buffers, which are managed collectively with Buffer Management.

ment. Such managers are sometimes referred to as "denominator" managers.

The final step down this slippery slope of measurements is averaged measurements. Averaged measurements are performance measurements. Usually, they tell us how we did over a long period of time. Examples of averaged measurements are: cost per drawing averaged for the quarter or year, cost per purchase requisition averaged over the fiscal year, cost per hour of system lab time, etc. Notice how many averaged measurements tend to become cost-focused. At this point, we should recognize this tendency in business to measure, record, track, (try to) manage and, at times, worship cost minimization everywhere. Again, averaged measurements, in and of themselves, are not all bad. They do provide information that may be useful to management, but, more often than not, managers try to use averaged measurements as operational measurements. Consider the logic. Imagine that you are flying an aircraft. Now, imagine that the altimeter gives you not the current altitude but the average altitude over the last 100 miles. Could you land the aircraft safely with such an altitude measurement?

### MEASUREMENTS IN CONFLICT

In the words of a colleague, we measure things that are mere observable quantities, and we act as if we could control them directly. We try to use performance measurements as operational measurements for day-to-day decision making. In this morass of performance measurements (old, new, local, normalized, averaged), we have no effective operational measurements for day-to-day decision making in a product development organization.

Trying to use performance measurements as operational measurements causes conflicts for managers and employees. All employees and managers who are subjected to incorrect operational measurements face frequent conflicts, between the choices that improve their measurements and the choices that they know are best for the greater organization or business.

For example, the purchasing manager who is measured on the increasing the number of purchase orders per purchasing agent avoids hiring more people, because doing so degrades his measurement. As a result, components required by manufacturing are delayed due to the queue at purchasing. This leads to product shipments to customers being late which leads

to lower revenues short term and lost customers long term.

Another example, the CAD manager who is measured on how well he controls costs in his department doesn't send designers for necessary training, because doing so increases that department's costs and degrades the department's measurement. As a result, drawings required by many other parts of the organization (engineering, tooling, purchasing, etc.) are delayed due the queue at the CAD department (designers do things manually because they could not attend the training that taught them how to do things faster with automation tools). This can lead to long delays, which again can hurt the bottom line and upset customers.

### MILESTONE PROJECT MANAGEMENT

Typically in product development, projects are broken up into a series of milestones that are often managed at a departmental level. Consequently, project management in this paradigm revolves around measuring the performance of each department on meeting their milestones. This causes another conflict for such organizations. Do they provide a short milestone estimate for the good of the project? Or do they provide a longer, padded milestone estimate for the good of satisfying their measurement that may lengthen the project to an unacceptable duration? Furthermore, these milestone measurements almost certainly guarantee that no projects will finish early (since no one wants to admit that they padded their milestone estimates) and many finish late (or cut scope or exceed budget to finish on time).

### THE CRITICAL CHAIN METHOD

Goldratt's Critical Chain Method<sup>1,2</sup> (See insert box ) focuses on the project as a whole, not on intermediate milestones. It establishes for any project, product development or otherwise, a series of buffers to protect against uncertainty in the project. The buffers provide focus and early warning in order to protect the due date of the project. In a product development system, where multiple projects are usually occurring simultaneously and being performed by a finite pool of resources,

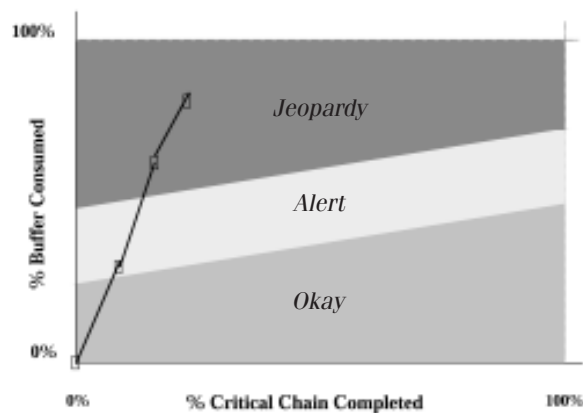


Figure 2 Sample Buffer Report

the Critical Chain Method yields a matrix or system of buffers.

During project execution, the people doing the work in each project are regularly (at least weekly) updating task status (reporting time estimates in the form: "number of days remaining on this task") in such a way that the consumption of each buffer in the system can be measured. By measuring the percentage of each buffer consumed relative to the percentage of the work completed on the chain of work associated with that buffer, a manager is able to measure the status or health of a project at any given time. A survey of all the buffers provides a measure of the status or health of all the projects in the product development system.

### BUFFER MANAGEMENT AS AN OPERATIONAL MEASUREMENT

Buffer Management is the name given to the process of measuring buffer status and then using that information to make operational decisions that will ensure that all the projects are completed successfully. For example, Figure 2 is a sample buffer report for a single project. The line indicates that the buffer is being consumed rapidly relative to the amount of progress being made in executing the Critical Chain of the project. Such a pattern would warrant an operational decision to be made that would help recover the buffer and get the project back on track.

Let's see if Buffer Management is an effective operational measurement for product development. First, Buffer Management provides an instantaneous "snapshot" of the status or health of the project. It tells us how we are doing, not how we did. It is, in fact, an "out the windshield" look. Second, Buffer Management creates a

feedback loop as it answers the question "How is the project doing today?" Depending on the answer to that question, we may make an operational decision that affects the value of the buffer. For example, referring again to Figure 2, if the operational decision to get the project back on track was to schedule some extra lab sessions for software testing (i.e. software product development project example), then the affect of that decision would most likely recover the buffer for the project. That is to say, it would directly affect the value of the buffer measurement.

Therefore, we can easily conclude that Buffer Management is an effective operational measurement for product development. In fact, experience with Buffer Management shows that it is a powerfully effective operational measurement system that can significantly improve the operations and business results of any product development organization.

### THE TOC MEASUREMENTS TRIANGLE

Let's now revisit the measurements triangle using the perspective of the Theory of Constraints (TOC). Well respected as a system level approach to improving business performance, TOC strongly advocates that performance measurements should be expressed at only a system level. Anything less would lead to local or sub-optimization of the system. Examples of system level performance measurements for product development should be centered on answering the following questions:

- Are project deliveries satisfying customer needs (e.g. on-time delivery)?
- Are projects getting done faster (e.g. interval reduction)?
- Are we getting more projects out the door?
- Do we have more capacity now to take on new projects?
- Is our THROUGHPUT going up?

We have already concluded that the operational measurement for product development should be TOC Buffer Management.

That brings us, finally, to individual measurements. In his 1982 book, *Out of the Crisis*<sup>3</sup>, Dr. W. Edwards Deming states that

one of the 7 Deadly Diseases of quality is "evaluation of performance, merit rating, or annual review of workers." In a 20-page diatribe, Deming makes no bones about his distaste for management by objective (MBO), which he aptly describes as management by fear.

If we couple Deming's astute analysis with Goldratt's "Tell me how you are going to measure me and I will tell you how I will behave" quote, we are left with the conclusion that effective individual measurements should be tied to their behavior not their output or performance.

In implementing TOC Buffer Management at Lucent, we have learned that there are two key behaviors peculiar to TOC that must be developed by individuals in the product development organization to be successful in the new paradigm:

1. Operating in relay race mode
2. Protecting project buffers

A practical list of questions that can be asked to individuals to measure their

There is no question that individual measurements derived from the above questions tend to be "softer" measurements. Again, from experience, individual performance review or individual coaching changes from a quantitative analysis to a qualitative or subjective analysis. While this may initially make the transition to the TOC paradigm hard for management, it is very much consistent with the Leadership style of management that Deming professed. Ultimately, the TOC paradigm is able to truly empower everyone in the product development organization. Figure 3 summarizes the TOC measurements triangle.

### CONCLUSION

Introducing Goldratt's TOC based Critical Chain Method into product development organizations will not be successful without developing a comprehensive set of measurements by which to manage the new system. TOC performance measurements should be at a system level and tied

closely to business strategy and customer satisfaction. TOC operational measurements should revolve around Buffer Management. And, TOC individual measurements should focus on behavior not individual output or performance.

This comprehensive set of measurements is far more effective than any other measurements in use today. It enables the entire product development organization to make day-to-day decisions that are consistently in the best interest of the business and directly improve their performance and the bottom line. Furthermore, managers are able to truly align the

strategies of the business with the day-to-day behaviors of the people doing the work.

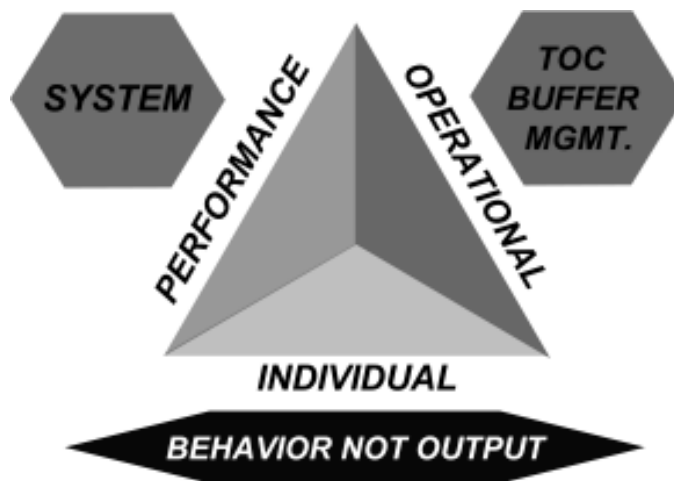


Figure 3 The TOC Measurements Triangle

progress in embracing these new behaviors which are peculiar to the TOC paradigm are:

- Are people providing task updates regularly?
- Are people announcing finishes immediately?
- Are people prioritizing their work according to buffer guidelines?
- Are people on the Critical Chain staying focused and avoiding interrupts?
- Are people subordinating to the Critical Chain?
- Are people starting tasks early?

1. Goldratt, Eliyahu M., *Critical Chain*, North River Press, 1997.
2. Newbold, Robert C., *Project Management in the Fast Lane*, St. Lucie Press, 1998.
3. Deming, W. Edwards, *Out of the Crisis*, MIT Press, 1982.